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Development of a Multi Purpose Tool for Simple Agricultural Practices

Adedipe J.O[1], Raji A.A[1], Odetoyinbo A.P[1], Agbonavbare O.R[1], Onifade A.O[2]
1. *Federal College of Forestry, P.M.B. 5087 Jericho, Ibadan.*
2. *Forestry Research Institute of Nigeria, Ibadan.*

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ABSTRACT: The developed machine was fabricated and tested; materials used for construction were locally sourced for and the machine requires no skill to operate. The operations of the machine were compared to human methods of carrying out similar tasks. It was observed that the multipurpose tool was more effective, faster and economical. It was observed that the multipurpose tool worked faster than the other method in the three (3) farm practice tested. Weeding took 0.028m/s against 0.015m/s for the tool and cutlass/hoe respectively. Ploughing was done in 0.028m/s using the tool while it took 0.008m/s using cutlass/hoe, while leveling was done in 0.051m/s and 0.037 m/s using the machine and cutlass/hoe respectively.
The developed machine had an efficiency of 90%, 82% and 97% when used for weeding, ploughing and leveling respectively.Labor charge is half of manual method, which makes it more economical.
Keywords: Developed, Weeding, ploughing, leveling, efficiemcy

I. INTRODUCTION

Over the years, agricultural practices have been carried out by small holders cultivating between 2 to 3 hectare, using human labor and traditional tools such as wooden plough, leveler, mallet, spade etc. These tools are used for land preparation, for sowing of seeds, weeding, and harvesting. Modern agricultural equipment is not used by small land holders because they are too expensive and difficult to acquire. By adopting scientific farming methods, we can get maximum yield and good quality crops which can save a farmer from going bankrupt but majority of farmers still uses primitive method of farming technique due to lack of knowledge or lack. Agricultural mechanization is the use of mechanical devices or system to replace human muscle in all forms and at any level of sophistication in agricultural production. In order to reduce tedium and drudgery, improve timeliness and efficiency of various farm operations, bring more land under cultivation, preserve the quality of agricultural produce, provide better rural living condition and markedly advance the economic growth of the rural sector (Anazodo, 1996).Ploughs, ridgers, and weeders are all seasonal implement before seed planting. Farmers can do much to increase crop production especially grains if drudgery can be reduced or totally removed from their planting operations.

Our purpose is to combine all the individual tools and fabrication of multipurpose equipment which is used for land preparation, sowing, leveling to provide farmers with multipurpose equipment which implements all the scientific farming techniques and reduce the cost of labour and handling cost of machines.

Benefits of a multipurpose farm tool

i. It is a simple singular device that can enhance simpleploughing, leveling and weeding practices
ii. It does not cause soil compaction because it is light in weight.
iii. It can be operated by skilled and unskilled operators and does not require much human effort.
iv. It increases labor productivity and reduce drudgery among subsistent farmers.

Description of the Multipurpose Tool

The machine comprises of the following;

i. Main Frame… The main frame is the skeletal structure of the multipurpose farm device on which all other components are mounted and it sits on the driving wheels.
ii. Drive wheel … The wheels are located at both ends of the frame and held together by a shaft. They are circular in shape and have "spokes" which are used to support the centre bushing or hub.

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Design of critical speed for rotating shaft

`Fromthe free body diagram of the shaft and wheel;

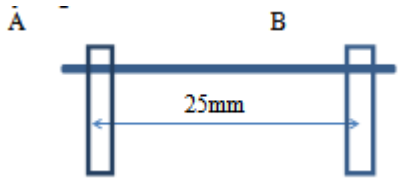

Figure 1: Free body diagram of the arrangement of the wheels

$F = \frac{1}{2\pi}\left\{\frac{g[W1I1+W2I2]}{[W1I^21+W2I^22]}\right\}^{1/2}$

And $I = \pi d4/64$

F ….. Critical speed

W ….. Weight of wheel

I ….. Static deflection of wheel

d ….. Diameter of shaft

$$I = \pi d4/64 = (3.14 \text{ X } 0.024)/\ 64$$

$$I = 7.85 \text{ x } 10^{-9}$$

Therefore:

$F = \frac{1}{6.28}\left\{\frac{9.8[(5 \text{ X } 7.85 \text{ X } 10^{-9})+(5 \text{ X } 7.85 \text{ X } 10^{-9})]}{[(5 \text{ X } (7.85 \text{ X } 10^{-9})^2+ (5 \text{ X } (7.85 \text{ X } 10^{-9})^2]}\right\}^{1/2}$

F = 5.5KN

iii. Cutting frame … The Cutting frame is a detachable attachment. It has a rectangular cutting blade that are held by square pipes and flat bar. The blade is tilted at an angle to enhance cutting process. This attachment is usually screwed to the rear part of the device when it is to be used.

Design of cutting frame

A force of 10.5N is required by a rotary lawn mower to cut grass smoothly; this force was assumed as the required force at the cutting blade for weeding.

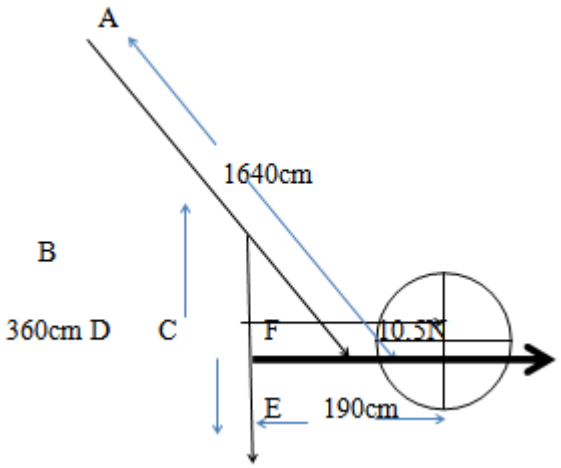

Figure 2: Free body diagram showing active forces

To determine the force applied while in use;

$\text{Sin } \theta = DC/BC = 10.5/BC$ (assuming the pole is inclined at an angle of 45^0)

$BC = 10.5/\text{Sin } 45 = 10.5/0.7071 = 4.85N$

(This is the applied force required by the operator during cutting operation)

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Weight of cutting frame assembly

Assuming; Blade length
$= 460\text{mm}$, Blade radius
$= 16\text{mm}$

But $M = \rho v = \rho\pi r^2 l$ (ρ for steel $= 8{,}050\text{kg/m}^3$)

$M = 8{,}050 \times 3.14 \times 0.016^2 \times 0.46 = 2.98\text{kg}$

iv. **Leveling frame** … The leveling frame is another detachable attachment for the multipurpose tool. It has rectangular blades, but not suitable for cutting. The leveling blade was designed in a pair and assembled horizontally with a spacing of 5mm apart; this is to allow soil fall over through the space when in use. A height of 280mm, a width of 75mm, blade length of 460mm and a leveling blade thickness of 20mm were chosen for this design.The blades are held by square pipes and flat bar. The blades are rectangular in shape and aligned horizontally to ensure smoothness when covering or leveling a cultivated soil. This attachment can be used when screwed to the rear part of the device.

v. **Chiseling (Ploughing) pair** … The chiseling pair is an implement attached to the rear part of the multipurpose device. It is rectangular in shape with chisel-like tips for plouhing. The chisel-like tips penetrates the soil when driven and drags it. An angle of inclination of 75^0 was selected to ensure a level of soil penetration when driven. A height of 280mm was selected to align with the height of the frame; a width of 25mm and a chiseling teeth thickness of 20mm were also assumed.

vi. **Driving rod** … The driving rod was designed to be adjustable to make it suitable for variations in different heights of operators. It helps in transmitting motion from the operator to the wheels.

Performance test

The multipurpose tool was used to carry out secondary weeding, ploughing, and leveling on a cultivated piece of land. Testing of the tool was done in three (3) phases and replicated five (5) times each, to observe each of the three (3) attachments. The time to carry out each test was recorded. Similar practices were then carried out using human labor (cutlass and hoe), the times used were also recorded and the mean of the two were compared.

Evaluation Parameters

These include the working speed, efficiency and labor cost of the machine.

a. **The working speed**… is the distance covered over a given time.

Mathematically $V = d/t$

Where V …….working speed (m/s)
d …….distance covered (m)
t …….. time (s)

b. **Efficiency (%)…** The efficiency of the machine was calculated using the equation below:

Efficiency $= A1/A2$

Where
A1 (area well worked upon per hour) = L1 x B1
A2 (total area per hour) = L2 x B2
L ……. Length/distance covered (m)
B ……. Breadth/ width of attachment (m)

c. **Labor cost….** For this study, the cost of labor is the cost expended during each of weeding, ploughing and leveling; as at the time when the machine was taken to be tested. The cost of using the manual method was calculated per sqm area and the equation below was used.

$$\text{Cost per unit area} = \frac{\text{cost per hour}}{\text{area covered}}$$

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Figure 3: Complete assembly of machine

Table 2: Comparison of multipurpose tool to use of cutlass/hoe Mean working speed

Farm practice	Multipurpose tool (m/s)	Cutlass/Hoe (m/s)
Weeding	0.028	0.015
Ploughing	0.028	0.008
Leveling	0.051	0.037

The table above shows the comparison of the working speeds of the multipurpose tool and cutlass/hoe when used to for weeding, ploughing and soil leveling. It was observed that weeding took 0.028m/s against 0.015m/s for the tool and cutlass/hoe respectively. Ploughing was done in 0.028m/s using the tool while it took 0.008m/s using cutlass/hoe, while leveling was done in 0.051m/s and 0.037 using the machine and cutlass/hoe respectively. This suggests that the multipurpose tool worked faster than the other method in the three (3) farm practice tested.

Efficiency (per hour)

$$\text{Efficiency} = A1/A2$$
$$A1 = L1 \times B1$$

Weeding

$$A1 = 82 \times 0.46 = 37.72\text{m}^2$$
$$A2 = 91 \times 0.46 = 41.87\text{m}^2$$

Thus;

$$\text{Efficiency during weeding} = 37.72/41.87 \times 100 = 90\%$$

Ploughing

$$A2 = 41.87\text{m}^2$$
$$A1 = 75 \times 0.46 = 34.5\text{m}^2$$

Thus;

$$\text{Efficiency during ploughing} = 34.5/41.87 \times 100 = 82\%$$

Leveling

$$A2 = 41.87\ \text{m}^2$$
$$A1 = 89 \times 0.46 = 40.94\text{m}^2$$

Thus

$$\text{Efficiency during leveling} = 40.94/41.87 = 97\%$$

The efficiency result above shows that the machine performed best when used for leveling and performed lowest when used for ploughing. These efficiencies are considered good for this study and can be improved upon with further research.

Cost estimate (₦)
Use of cutlass/hoe

$$\text{labor per hour} = ₦500$$
$$\text{Area in one hour} = 41.87\text{m}^2$$

Therefore

$$\text{Cost per unit area} = 500/41.87$$
$$\text{cost per unit area} = ₦12 \text{ per sq m}$$

Comparing the working speed against cost estimate, it was observed the tool attracts approximately half of the cost for manual labour; this suggests that the tool can be considered more economical than the use of cutlass/hoes.

II. CONCLUSION

The machine was successfully fabricated and tested; materials used for construction were locally sourced for and easy to reach. The machine requires no skill to operate. The operations of the machine were compared to human methods of carrying out similar tasks. It was observed that the multipurpose tool was more effective, faster and economical. It was observed that that the multipurpose tool worked faster than the other method in the three (3) farm practice tested. Weeding took 0.028m/s against 0.015m/s for the tool and cutlass/hoe respectively. Ploughingwas done in 0.028m/s using the tool while it took 0.008m/s using cutlass/hoe, while leveling was done in 0.051m/s and 0.037 using the machine and cutlass/hoe respectively.

The developed machine had an efficiency of 90%, 82% and 97% when used for weeding, ploughing and leveling respectively. It is economical and does not attract any cost of usage, unlike manual method where labor charge is approximately ₦12 for a unit area.

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APPENDIX

A pictorial view of the tool with a leveling tool attached